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Chinook Salmon Captive Rearing

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INTRODUCTION

The combined counts of returning spring and summer chinook salmon *Oncorhynchus tshawytscha* to the Snake River Basin were the lowest on record in 1994 (4,475) and again in 1995 (2,787). For perspective, from 1962 to 1971 an average of 148,000 adult anadromous salmonids per year crossed Ice Harbor Dam into the Snake River Basin. Most of these returnees were produced in and destined for production areas located upstream of Lower Granite Dam. The spring/summer chinook salmon component of the run was comprised primarily of wild fish and accounted for about 40% of the run, an average of 59,900 fish annually. In contrast, 3,915 adult spring and summer chinook salmon passed upstream of Lower Granite Dam in 1994, including 1,517 and 305 naturally-produced spring and summer chinook salmon, respectively.

Idaho Department of Fish and Game's (IDFG) long-term objective for salmon management is to maintain Snake River salmon populations at levels that will provide sustainable harvest (IDFG 1996). Restoring currently depressed chinook salmon populations to historic levels is a prerequisite to this condition. Artificial propagation of spring and summer chinook salmon in the Salmon River basin, through Lower Snake River Compensation Plan (LSRCP) and Idaho Power Company hatcheries, was initiated to compensate for lost production and productivity caused by the construction and operation of private and federal hydroelectric facilities in the Snake River. The mitigation approach was to trap, spawn, and rear a portion of the historically productive local brood stock to produce a large number of smolts (Bowles 1993). When chinook salmon trapping began in 1981 as part of the LSRCP, it was assumed that enough chinook salmon adults would return for harvest and continued hatchery production needs. It was also assumed that hatchery programs would not negatively impact the productivity or genetic viability of target or other populations and that natural populations would remain self-sustaining even with hydropower dams in place. In reality, productivity (survival rates) of wild Snake River chinook salmon declined abruptly with completion of the federal hydroelectric system by the mid-1970s (Petrosky and Schaller 1994). Survival rates used in the hatchery mitigation program models were substantially overestimated. Hence, hatchery programs have been unable to mitigate for the dams or stem the decline of target populations, and numbers of naturally produced salmon declined at various rates throughout the Snake River Basin. Spring/summer chinook salmon returns have been insufficient to meet artificial and natural smolt and adult production predictions, much less provide a consistent harvestable surplus of adults (Hassemer 1998).

The only way to prevent further decline and secure eventual recovery of Snake River stocks is to provide historical levels of survival in the migration corridor. Pending changes in the mainstem hydroelectric system, our immediate challenge becomes one of preserving the existing metapopulation structure of Snake River chinook salmon so future recovery actions are possible. The listed Snake River spring/summer chinook salmon evolutionary significant unit (ESU) consists of 38 sub-populations (i.e. breeding units or stocks), 28 of which exist in the Salmon River Drainage (NMFS 1995). Preserving the current stock or metapopulation structure is consistent with the pre-decisional Snake River Salmon Recovery Plan (Schmitten et al. 1997, in review), and also supports the Northwest Power Planning Council's goal of maintaining biological diversity while doubling salmon and steelhead runs (NPPC 1994). Metapopulation structure (or biodiversity) can be maintained by preventing local or demographic extinctions.

The IDFG initiated a captive rearing program for populations at high risk of extinction to maintain metapopulation structure. Captive rearing is a short-term approach to species preservation. The main goal of the captive rearing approach is to avoid demographic and environmental risks of cohort extinction; maintaining the genetic identity of the breeding unit is an important but secondary objective. The strategy of captive rearing is to prevent cohort collapse of the specified target populations by providing captively reared adult spawners to the natural environment, which in turn, maintain the continuum of generation to generation smolt production. Each generation of smolts, then, provides the opportunity for population maintenance or increase should environmental conditions prove favorable for that cohort.

The captive rearing program was developed primarily as a way to maximize the number of breeding units that could be addressed while minimizing intervention impacts. We collect only enough juveniles from the target populations to provide what we feel are adequate spawners, about 20, to ensure that minimum demographic spawner goals are met. (According to members of the Stanley Basin Sockeye Technical Oversight Committee, it is not unreasonable to assume that 20 fish could encompass 95% of the genetic diversity of the population.) The appropriate number of juveniles to collect remains somewhat speculative at this time because of the uncertainty associated with the ability of the captive rearing approach to produce adults with desired characteristics for release into the wild (Fleming and Gross 1992, 1993; Joyce et al. 1993; Flagg and Mahnken 1995). Juveniles would be collected each year from cohorts of low resiliency populations, those expected to return 10 or fewer spawning pair to their respective spawning areas. In order to meet program objectives, we must be able to produce an adequate number of adults with the proper morphological, physiological, and behavioral attributes to successfully spawn and produce viable offspring in their native habitats.

Little scientific information regarding captive propagation techniques for Pacific Salmonids was available at the inception of this program. Flagg and Mahnken (1995) reviewed the status of captive broodstock technology. Following Flagg and Mahnken's (1995) work the IDFG captive rearing program was initiated to develop the technology for captive propagation of chinook salmon and to monitor and evaluate captive-reared fish during both the rearing and post-release/spawning phases. In addition to technology development, the IDFG program also addresses population dynamics and population persistence concerns. These population level concerns are: 1) maintaining a minimum number of spawners in high-risk populations, and 2) maintaining metapopulation structure by preventing local extinctions.

This report documents activities under the captive-rearing program from January 1, 1998, through December 31, 1998. Also, activities completed since the inception of the program are summarized in this report. This work is coordinated with the Northwest Power Planning Council's Fish and Wildlife Program (NPPC 1994) and is identified as projects 9700100 and 9801002. Funding was provided through the Bonneville Power Administration under contracts 97-BI-97538 and 98-BI-63416.

STUDY AREA

Three streams were selected for the initiation of the captive rearing program: the Lemhi River; the East Fork of the Salmon River (EFSR); and the West Fork Yankee Fork of the Salmon River (WFYF) (Figure 1). With the exception of the Lemhi River, streams reside in relatively sterile watersheds draining granitic parent material associated with the Idaho batholith. Water quality is high and water temperatures are ideal for chinook salmon rearing. Habitat

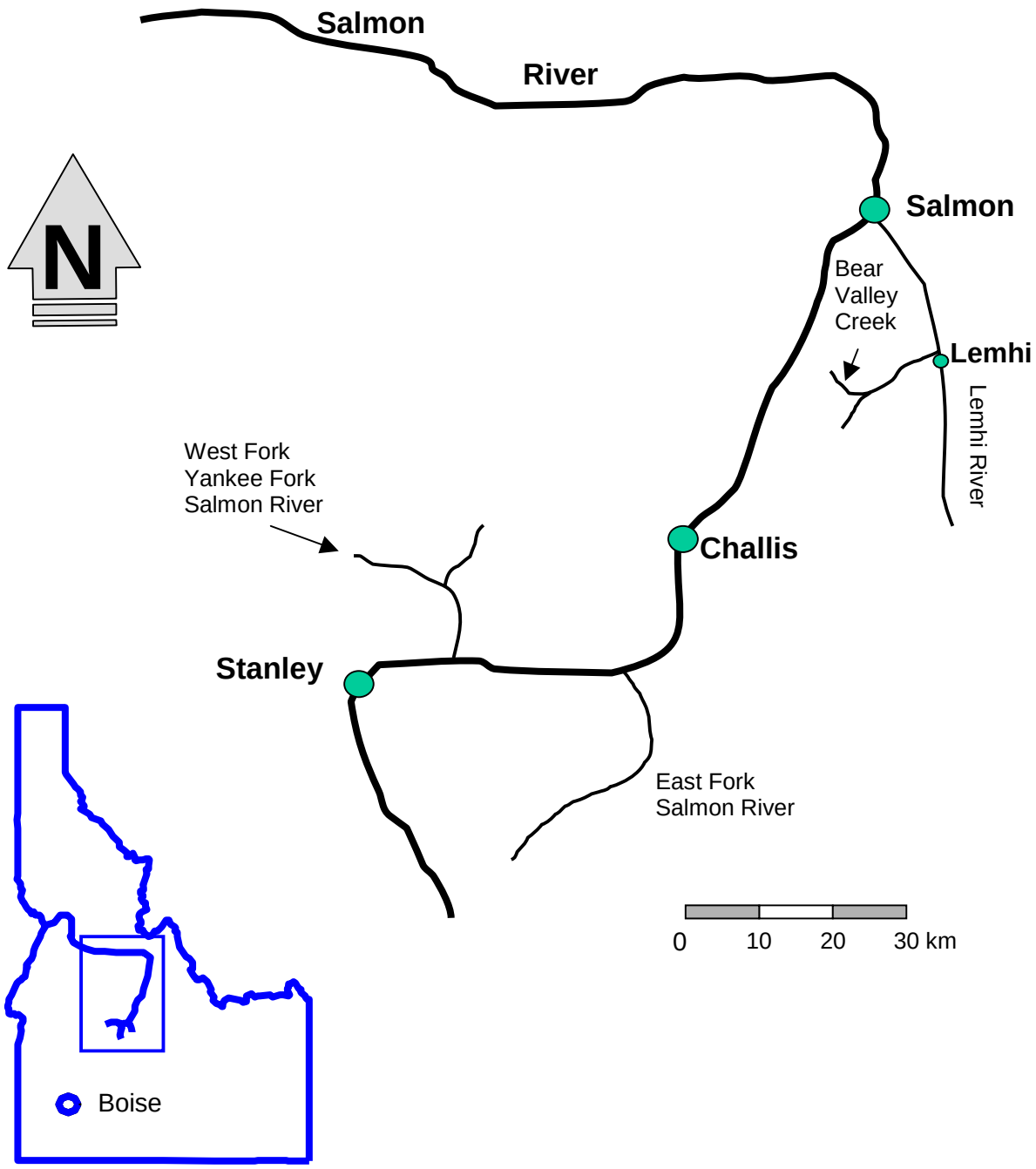

Figure 1. Location of Idaho Department of Fish and Game spring/summer chinook salmon captive rearing program study streams.

quality is relatively pristine with some localized riparian degradation, sedimentation, and impact from grazing, mining, logging, road building, and irrigation diversion.

The Lemhi River drains productive basaltic parent material resulting in rapid fish growth. The lower river travels through private land developed extensively for agriculture and grazing. Stream habitat typically reflects C channel conditions (Rosgen 1985). Bear Valley Creek, a tributary of Hayden Creek, which flows into the Lemhi River approximately 30 km upstream of its confluence with the Salmon River, was also selected as a captive chinook salmon release site. Bear Valley Creek reflects near pristine B and C channel conditions.

The WFYF drains granitic parent material adjacent to the Frank Church Wilderness. Primarily roadless, the stream has remained non-impacted by land use practices for nearly half a century. Stream habitat typically reflects B and C conditions.

The EFSR drains granitic parent material, and is generally less productive than the Lemhi River system. The lower 30 km of the stream runs through ranch and grazing property developed during the last century. The upper reaches of the EFSR reflect near pristine conditions with little historical disturbance from logging, mining, or agriculture. Stream habitat typically reflects B and C conditions.

PROGRAM HISTORY

We collected brood year 1994 juvenile spring chinook salmon parr from the Lemhi River, West Fork Yankee Fork, and East Fork Salmon River in the fall of 1995 to initiate the captive rearing program. Each stock produced fewer than 20 redds in 1994 and is expected to produce similar or diminishing escapement for the next several years. Following collection, fish were held at the IDFG Sawtooth Fish Hatchery. In the spring of 1996, additional yearlings were collected from the Lemhi River and transferred to Sawtooth Fish Hatchery.

In the spring of 1996, fall and spring-collected fish were transferred to the IDFG Eagle Fish Hatchery. In May 1996, approximately one-half of the fish were transferred to the National Marine Fisheries Service Manchester Marine Laboratory for seawater rearing. The other half remained in freshwater at the IDFG Eagle Fish Hatchery. In July of 1996, all fish were examined for signs of sexual maturation (precocial males). The rate of precocial male development was very low, less than 6% in each of the three stocks. This was a very positive finding as precocial maturation is a concern in captive propagation programs.

In July 1997, brood year 1994 fish were again sorted to identify and isolate maturing jacks (three-year-old males). Maturing seawater-reared jacks were transferred back to Eagle Fish Hatchery for final maturation in freshwater. Although the rate of jack maturation varied among the three stocks, it was not regarded as excessively high (less than 30% overall). No difference was found in maturation rate for freshwater or seawater rearing groups and fish health was good. In 1997, a small number of maturing jacks (up to four) from each stock were fitted with radio transmitters and outplanted to their source streams. Movement and behavior were monitored. The 1997 (jack) outplanting was considered successful. In general, the fish remained in the streams where they were released, and exhibited searching and movement patterns typical of natural origin fish. It was encouraging to observe that even though the fish had been reared almost entirely in captivity, with no opportunity for normal migration and homing behaviors, they remained within their source streams after release.

In July through August 1998, we conducted age-4 maturation sorts in brood year 1994 captive chinook salmon. Maturing seawater-reared fish were transported from the Manchester Marine Laboratory to Eagle Fish Hatchery where they were staged with maturing freshwater

groups. In August 1998, maturing brood year 1994 and 1995 chinook salmon were outplanted to the Lemhi River system (54 age-4 females and 18 age-3 males), and the West Fork Yankee Fork (35 and 9 age-4 females and males, respectively). Because of demographic risks, no adults were released to the EFSR in 1998. Using radio telemetry, we identified approximately 25 and 4 captive fish-produced redds in the Lemhi River and West Fork Yankee Fork systems in 1998. Investigations of spawning variables (e.g., gamete quality, and survival to eyed-egg) and comparisons between rearing strategies (seawater/freshwater) were also conducted in 1998. In cooperation with the Shoshone-Bannock Tribes and with approval from NMFS, eyed-eggs produced from 1998 hatchery investigations were planted in streamside or instream incubation devices. Additional milt was cryopreserved in 1998. Immature brood year 1994 chinook salmon remain at NMFS and IDFG facilities. Age-5 maturation is expected in 1999.

Brood year 1995 collections were conducted in the Lemhi River in the fall of 1996 and the spring of 1997. No brood year 1995 juveniles were collected from the West Fork Yankee Fork or EFSR as a result of low adult spawner escapement in 1995. As indicated above, maturing, age-3 males from this brood year were outplanted in 1998 with brood year 1994 Lemhi River female chinook salmon. We cryopreserved milt from this brood in 1997 and 1998. Immature brood year 1995 Lemhi River fish remain on station at Manchester Marine Laboratory and Eagle Fish Hatchery. Age-4 and age-5 maturation is expected in 1999 and 2000, respectively.

In 1997, brood year 1996 parr were collected in the fall of 1997 from the Lemhi River, West Fork Yankee Fork, and EFSR. In addition, yearling West Fork Yankee Fork juveniles were collected in the spring of 1998. Due to low EFSR adult escapement in 1996, only five parr were collected from that system in 1997. For all three stocks, less than 5% age-2 maturation (in males) was detected at sorting in 1998. Immature brood year 1996 fish remain in culture at NMFS and IDFG facilities. Age-3, 4, and 5 maturation is expected in 1999, 2000, and 2001, respectively.

Brood year 1997 parr were collected from the Lemhi River and West Fork Yankee Fork in the fall 1998. Due to low EFSR adult escapement in 1997, no parr were collected from that system. Immature brood year 1997 fish remain in culture at NMFS and IDFG facilities. Age-2, 3, 4, and 5 maturation is expected in 1999, 2000, 2001, and 2002, respectively.

METHODS

Captive propagation of chinook salmon is a relatively new field and because of this, the role of the Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC) is very important to the success of the program. The CSCPTOC provides a forum of peer review and discussion of all activities and propagation protocols associated with this program. This allows for an adaptive management approach to all phases of the program, which supports technological and overall program development, as new information becomes available.

The goal of this project is to develop and test chinook salmon captive rearing, a specific form of captive propagation. To achieve this goal, program activities are divided into two functional bodies: 1) fish culture and 2) field evaluations. Success of the program is dependent on synchronous development of effective rearing technology and the evaluation of post-release adult chinook salmon behavior and spawning success. The methods described here cover both aspects of our evaluations.

Juvenile Collections

Juvenile chinook salmon are collected using rotary screw traps (E.G. Solutions, Corvallis, OR) and beach seines. Rotary screw traps are passive capture devices generally positioned in the thalweg of the stream. Stream flow turns a baffled cylinder that funnels captured fish to a live well for temporary holding. Idaho Department of Fish and Game and cooperator personnel from the Shoshone-Bannock Tribes attend traps on a daily basis. Captured juveniles may be temporarily held in streamside live boxes until transfer to Sawtooth Fish Hatchery for initial rearing.

Beach seines are used to collect juvenile chinook salmon over a broad range of stream distance. Following the location of juveniles by snorkeling, a beach seine is positioned downstream of the target assemblage of fish. Snorkelers then work cooperatively with seine handlers to capture fish. Fish are temporarily held in streamside live boxes until transfer to Sawtooth Fish Hatchery.

Following collection, all juvenile chinook salmon are Passive Integrated Transponder (PIT)-tagged and visual-implant tagged for stock identification and tracking.

Fish Culture

Facilities and Protocols

Eagle Fish Hatchery is the primary Idaho site for the culture of captive-reared chinook salmon. Specific pathogen free artesian water from five wells is currently in use. Artesian flow is augmented through the use of four separate pump/motor systems. Water temperature remains a constant 13.3°C and total dissolved gas averages 100% after degassing. Water chilling capability was added in 1994. Chilled water is used for incubation and for final maturation rearing. Backup and system redundancy is in place for degassing, pumping, and power generation. Nine water level alarms are in use and linked through an emergency service operator. Additional security is provided by limiting public access and by the presence of three on-site residences occupied by IDFG hatchery personnel.

Facility layout at Eagle Fish Hatchery remains flexible to accommodate culture activities. Several fiberglass tank sizes are used to culture chinook salmon from pre-smolt to the adult stage including: 1) 1 m diameter semi-square tanks (0.30 m^3), 2) 2 m diameter semi-square tanks (1.42 m^3), 3) 3 m diameter circular tanks (6.50 m^3), 4) 4 m diameter semi-square tanks (8.89 m3), and 5) 6 m diameter circular tanks (44.5 m^3). One-meter tanks are used to acclimate pre-smolts to hatchery diets following collections. Two-meter tanks are used to rear juveniles, by stream origin, to approximately 20 g. Three and four meter tanks are used to rear juveniles to approximately 1,000 g and to hold fish by stream origin prior to distribution to natal waters. Six-meter tanks are used to rear fish to age-3 and 4. Flows to all tanks are maintained at no less than 1.5 exchanges per hour. Shade covering (70%) and jump screens are used where appropriate. Tank discharge standpipes are assembled in two sections (“half pipe principal”) to prevent tank dewatering when removed for tank cleaning.

Sawtooth Fish Hatchery was completed in 1985 as part of the Lower Snake River Compensation Plan and is located on the Salmon River in the Stanley Basin. Sawtooth Fish

Hatchery personnel and facilities have been used continuously since 1995 to hold pre-smolts prior to their transfer to Eagle Fish Hatchery. Following collection, pre-smolts are held in 2 m semi-square fiberglass tanks by stream origin. All fish rearing occurs on specific pathogen free well water. Water temperature varies by time of year from approximately 2.5°C in January and February to 11.1°C in August and September. Back-up and redundancy systems are in place.

The IDFG provides daily staffing for the propagation of Snake River captive-reared chinook salmon. The fish are reared using standard fish culture practices and approved theraputants (for an overview of standard methods see Leitritz and Lewis 1976; Piper et al. 1982; Erdahl 1994; Bromage and Roberts 1995; McDaniel et al. 1996; Pennell and Barton 1996). The fish are fed a commercial diet produced by BioOregon (Warrenton, OR). The standard diet formulation is used until fish reach approximately 75 g after which time they receive a special brood diet enhanced with natural flavors from fish and krill. Rearing tank size varies with fish age. Rearing densities, diet ration, and tank size are managed to promote optimum growth and for the attainment of program objectives and goals. Individual fish weight is periodically monitored to insure that projected weights track closely with actual weights. Mortalities, both natural and maturation-related, are typically examined by a fish pathologist. Tissues are analyzed for common bacterial and viral pathogens. In addition, tissue samples are removed, frozen (-80°C), and transferred to NMFS for subsequent genetic analysis.

Egg and Fish Transfers

Eggs may be transferred between NMFS and IDFG facilities to meet program objectives. Eggs are shipped at the eyed stage of development using a commercial air service. Iodophor-disinfected eggs are packed at a conservative density in perforated shipping tubes, capped, and labeled to identify lineage. Tubes are wrapped with hatchery water-saturated cheesecloth and packed in small, insulated coolers. Ice chips are added to insure proper temperature maintenance and coolers are sealed with packing tape. Idaho Department of Fish and Game and NMFS personnel are responsible for shuttling coolers to and from air terminals. Eggs may also be transferred to remote field locations for incubation in streamside or instream incubation systems. Packing for this option is the same as that described above for interstate transfer.

Fish are transported to and from collection locations in truck-mounted, insulated tanks (typically 1,136 L capacity) with alarm and back-up oxygen systems on board. For longer duration trips (e.g., from NMFS Washington State facilities to Idaho), larger capacity truck-mounted tanks may be used (3,785 L and 9,463 L capacity). The IDFG obtains the appropriate permits for interstate transfer of captive chinook salmon to and from NMFS facilities. All vehicles are equipped to provide the appropriate conditions (temperature, oxygen, capacity) to facilitate safe transport of fish to and from specified destinations. In addition, all vehicles are equipped with two-way radios or cellular phones to provide routine or emergency communication capability. Fish are transported by IDFG or cooperator personnel. Prior to releasing transported fish at hatchery or remote release locations, transport and receiving water temperatures are tempered to fall within a 2.0°C range.

Maturation Sorting

In 1998, maturation and determination of sex in captive chinook salmon populations was examined using three techniques: 1) non-lethal genetic sex determination, 2) ultrasound determination, and 3) physical sorting. Genetic sex determinations were conducted in June and

July 1998 by Eric LaHood (NMFS Northwest Fisheries Science Center, Seattle, WA). To facilitate this process, fin tissue was sampled from anesthetized brood year 1994 and 1995 chinook salmon brood stocks at Eagle Fish Hatchery and Manchester Marine Laboratory on June 8 and 10, 1998, respectively. Tissue samples, stored in 95% ethanol, were transferred to NMFS for analysis. Ultrasound investigations were conducted at Eagle Fish Hatchery and Manchester Marine Laboratory by Dr. Kristen Arkush (University of California Bodega Marine Laboratory, Bodega Bay, CA). Brood year 1994 and 1995 fish were anesthetized and measured for weight (to the nearest 0.1g) and fork length (to the nearest 1.0 mm). Determination of sex was made by interpreting the degree of gonadal development as displayed on a visual monitor. Physical maturation sorts were conducted between July 31 and September 29, 1998. In general, sorting was conducted on a twice-weekly basis. Anesthetized brood year 1994 and 1995 chinook salmon were examined for external signs of maturation including changes in body coloration and the development of maturation-related morphological characteristics. In addition to appearance, maturation in male and female chinook salmon was interpreted from physical handling. Fish that were judged to be maturing were isolated, by stock, from general populations.

Fish Releases and Monitoring

Assembly of Adult Releases

Between August 17 and 19, 1998, maturing brood year 1994 and 1995 Lemhi River and brood year 1994 West Fork Yankee Fork captive chinook salmon were sorted to assemble final adult release groups. We used genetic sex, ultrasound, and physical sort information to assemble adult release groups. All fish destined for release were anesthetized, measured for weight (to the nearest 0.1 g) and length (to the nearest 1.0 mm), and fitted with numbered opercle tags (fastened with staples). At this time, some fish were implanted with radio transmitters. Fish within each population (Lemhi River and West Fork Yankee Fork Salmon River) were first stratified into groups based on degree of maturation and rearing history (freshwater or seawater). Individuals that received radio-transmitters were randomly selected from each to the stratification levels. Transmitters were inserted past the pharyngeal sphincter with the aid of a hand-held plunger. Vegetable oil was used to lubricate radio transmitters prior to insertion.

Radio tracking equipment was manufactured by Advanced Telemetry Systems (ATS). Model R2000 receivers were used in conjunction with three-element Yagi antennas. Type 201, model 10-28 (15 g dry weight) and model 5 (20 g dry weight) transmitters were used.

Release Sites

In 1998, pre-spawn adult releases were made to the Lemhi River, Bear Valley Creek, and the West Fork Yankee Fork on August 18, August 20, and August 21, respectively. No adult releases were made to the East Fork Salmon River in 1998. Transportation and tempering were conducted as described above. Pre-spawn adult releases were conducted according to protocols identified in the original permit application and conservation plan. All release sites were selected based on historical spawning information, and accessibility.

Lemhi River—The release site was located on the Karl Tyler ranch. The specific release location was adjacent to the L-60 irrigation diversion screen. The area is a known spawning location for spring chinook salmon. It is estimated that up to 80% of the spawning in the Lemhi River occurs within 13 km of the release location. The site was selected based on historical chinook salmon use, landowner cooperation, and the condition of the habitat (Tom Curet, IDFG Salmon Region, Fisheries Biologist personal communication).

Bear Valley Creek—The release site was located approximately 1.6 km upstream of the mouth of Bear Valley Creek. To ensure that fish remained in the release section, a temporary blocking weir was constructed at the downstream end of the evaluation section. A natural barrier was located approximately 2.0 km upstream of the lower blocking weir. An upstream trap was installed at the lower blocking weir to facilitate the capture and release of adult, wild/natural chinook salmon and bull trout *Salvelinus confluentus*.

West Fork Yankee Fork Salmon River—The release site was located near the Knapp Creek/Hay Creek trailhead. The release site is approximately 1.2 km upstream of the confluence of the West Fork and mainstem Yankee Fork Salmon rivers.

East Fork Salmon River—Although no adult chinook salmon were released from the captive rearing program in 1998, an evaluation site was established on the EFSR approximately 31 km upstream of the confluence of the East Fork and mainstem Salmon rivers.

Behavioral Observations

Following the release of pre-spawn adult chinook salmon, radio tracking was conducted on an every other day basis. The frequency of tracking increased to daily following first observations of spawning-related behavior. When radio-tagged fish were located, their positions were recorded on GPS receivers (Lowrance GPS model GlobalNav 212). If observers were able to make visual contact with specific radio-tagged fish, additional information was recorded including: stream habitat type; evidence of mate pairing; general health and condition of the fish; spawning behavior; evidence of redd construction/defense; and seawater/freshwater rearing history. If non-radio-tagged fish were located, observers recorded similar observational data. All captively-reared chinook salmon carried a visible external mark.

Hatchery Monitoring

Fish from each stock were retained to investigate several spawning variables, including gamete quality, fecundity, and egg survival to the eyed stage of development. Where possible, comparisons were made between seawater and freshwater rearing treatments.

Gamete Evaluations

Spawning followed accepted, standard practices as described by McDaniel et al. (1994) and Erdahl (1994). In general, eggs produced at spawning were divided into sub-lots (by female) and fertilized with milt from unique males. Milt was pre-harvested and examined for motility prior to use. Eggs were incubated by sub-lot to yield lineage-specific groups. Overall

egg quality was judged by examining egg size, clarity of ovarian fluid, and presence/absence of polarized or overripe eggs. Fecundities were developed by applying sub-sample weights (number of eggs per gram) to total egg weight for each female. Egg survival to the eyed stage was determined by subtracting dead or unfertilized eggs from the total estimated number of eggs for each female.

For the EFSR stock, a spawning matrix was developed by Dr. Madison Powell and Joyce Faler (University of Idaho Hagerman Fish Culture Experiment Station, Hagerman, Idaho) to minimize inbreeding and maximize genetic diversity. Fin tissue from maturing adults and samples of cryopreserved milt from three year-old males were analyzed for genetic differences using mitochondrial and nuclear DNA markers. Mitochondrial haplotypes and nuclear genotypes were identified in the maturing fish and used to construct the matrix. Crosses were prioritized for outcrossing similar maternal lineages followed by outcrossing similar nuclear genotypes.

Hatch Box Program

Eyed-eggs produced from 1998 spawning activities at Eagle Fish Hatchery were transferred to instream or streamside incubation boxes in cooperation with the Shoshone-Bannock Tribes. Instream incubation consisted of Jordan-Scotty boxes anchored to the channel bottom at locations with suitable water depth, velocity and substrate conditions. Streamside incubation systems consisted of Whitlock-Vibert hatch boxes placed in larger incubation environments (modified refrigerators) plumbed with flow-through spring water. Eyed-eggs produced from Lemhi River spawn crosses were transferred to one streamside incubator located adjacent to Hayden Creek, a tributary to the Lemhi River. The incubation site was approximately 7 km upstream of the confluence of Hayden Creek and the Lemhi River. Eyed-eggs produced from West Fork Yankee Fork spawn crosses were transferred to one streamside incubator located adjacent to the river approximately 3 km upstream of the confluence with the mainstem Yankee Fork Salmon River. East Fork Salmon River eyed-eggs were transferred to instream Jordan-Scotty boxes and one stream side incubator approximately 31 km upstream of the confluence of the East Fork and mainstem Salmon rivers. Approximately 300 eyed-eggs produced from EFSR spawn crosses were retained at Eagle Fish Hatchery as a safety net to preserve future program options.

Cryopreservation

Cryopreservation of milt from male donors has been used in the captive rearing program since 1997 and follows techniques described by Cloud et al. (1990) and Wheeler and Thorgaard (1991). Milt is cryopreserved and stored at three locations (Eagle Fish Hatchery, University of Idaho, and Washington State University) to spread the risk associated with freezing technique error and storage system failure. In 1998, milt from maturing captive chinook salmon from each stock was cryopreserved to preserve future program options.

Fish Health

The Eagle Fish Health Laboratory processed 98 cases involving 159 individual chinook salmon during this reporting period. Routine fish necropsies included investigations for viral, bacterial, and parasitic disease agents. The majority of samples analyzed in 1998 originated

from groups reared at Eagle Fish Hatchery. However, mortalities received from the Sawtooth Fish Hatchery shortly after field collection and adult chinook salmon transferred to Eagle Fish Hatchery from the Manchester Marine Laboratory were also necropsied at the Eagle Laboratory in 1998. Juvenile chinook salmon destined for transfer to the Manchester Marine Laboratory for seawater rearing are vaccinated for *Vibrio spp*. immunization. Chinook salmon held at Eagle Fish Hatchery receive periodic Aquamycin treatments (or prophylaxis) using medicated feeds. In addition, Erythromycin may be delivered to specific stocks through interperitoneal injection.

RESULTS

Brood Year 1996 Juvenile Collections

Lemhi River

In September and October 1997, 178 age-0 chinook salmon parr were collected from the Lemhi River and transferred to the Sawtooth Fish Hatchery for initial rearing.

West Fork Yankee Fork Salmon River

In September and October 1997, 104 age-0 chinook salmon parr were collected from the West Fork Yankee Fork and transferred to the Sawtooth Fish Hatchery for initial rearing. Between April and June 1998, 16 age-1 chinook salmon juveniles were collected and transferred to the Sawtooth Fish Hatchery.

East Fork Salmon River

In September and October 1997, five age-0 chinook salmon parr were collected from the EFSR and transferred to the Sawtooth Fish Hatchery for initial rearing.

Brood Year 1997 Juvenile Collections

Lemhi River

In September and October 1998, 147 age-0 chinook salmon parr were collected from the Lemhi River and transferred to the Sawtooth Fish Hatchery for initial rearing.

West Fork Yankee Fork Salmon River

In September and October 1998, 210 age-0 chinook salmon parr were collected from the West Fork Yankee Fork and transferred to the Sawtooth Fish Hatchery for initial rearing.

East Fork Salmon River

Due to low adult escapements into the EFSR in 1997, no juvenile collection effort was undertaken in 1998.

Fish Culture

The following information reflects culture history for the reporting period January 1, 1998, through December 31, 1998. During this reporting period, nine rearing groups were in culture at IDFG facilities. A summary of losses, transfers, and releases while in culture is presented in Tables 1, 2, and 3.

Brood Year 1994

At the beginning of the reporting period, 49 Lemhi River, 34 West Fork Yankee Fork, and 37 EFSR chinook salmon were on station at Eagle Fish Hatchery (Tables 1, 2, and 3). In June and September 1998, maturing Lemhi River (33), West Fork Yankee Fork (23), and EFSR (18) were transferred from the Manchester Marine Laboratory to Eagle Fish Hatchery to complete maturation in fresh water. In August 1998, 54 Lemhi River and 44 West Fork Yankee Fork maturing adults were released for natural spawning. Nine Lemhi River, seven West Fork Yankee Fork, and 34 EFSR adults (not released to spawn) completed maturation and were spawned in the hatchery. At the end of the reporting period, 7 Lemhi River, 2 West Fork Yankee Fork, and 12 EFSR brood year 1994 chinook salmon were in culture at the Eagle facility. Maturation is expected in 1999.

Brood Year 1995

Fifty-nine brood year 1995 Lemhi River chinook salmon were on station at Eagle Fish Hatchery at the beginning of the reporting period (Table 1). No West Fork Yankee Fork or EFSR brood year 1995 chinook salmon were collected. Fourteen maturing males were transferred to Eagle Fish Hatchery from the Manchester Marine Laboratory in June of 1998 to complete maturation in fresh water. Nineteen maturing males were released for natural spawning in 1998. Eight maturing males (not released to spawn) completed maturation at Eagle and were spawned in the hatchery. Thirty-six fish remained in culture at Eagle Fish Hatchery at the end of the reporting period. Brood year 1995 Lemhi River chinook salmon averaged 600 g at the end of the reporting period.

Table 1. Summary of losses and magnitude of mortality for four Lemhi River captive chinook salmon culture groups reared at IDFG facilities in 1998.

	Culture Groups			
	BY94	BY95	BY96	BY97
Starting Inventory (January 1, 1998)	49	59	177	147[a]
Eyed-Egg to Fry				
Undetermined	n/a	n/a	n/a	n/a
Mechanical Loss				
Handling	2	4	13	2
Jump-out	2	0	0	2
Non-infectious				
Lymphosarcoma	0	0	0	0
Other[b]	8	5	2	5
Infectious				
Bacterial	0	1	1	0
Viral	0	0	0	0
Other	0	0	7[c]	0
Maturation				
Mature Males[d]	0	8	2	0
Mature Females[d]	7	0	0	0
Other	2[e]	0	1[f]	3[f]
Relocation				
Transferred In[g]	33	14	0	0
Transferred Out[h]	0	0	110	0
Planted/Released[i]	54	19	0	0
Ending Inventory (December 31, 1998)	7	36	41	135

[a] Fall 1998 collections.
[b] Includes culling associated with cultural abnormalities, and all undetermined, non-infectious mortality.
[c] Attributed to parasitic copepod *Salmincola californensis* infestations.
[d] Spawned at Eagle Fish Hatchery.
[e] Mature fish with non-viable gametes.
[f] Unspawned, precocial males.
[g] Transferred from Manchester Marine Laboratory to Eagle Fish Hatchery for distribution and spawning.
[h] Transferred from Eagle Fish Hatchery to the Manchester Marine Laboratory for seawater rearing.
[i] Released for volitional spawning in 1998.

Table 2. Summary of losses and magnitude of mortality for three West Fork Yankee Fork Salmon River captive chinook salmon culture groups reared at IDFG facilities in 1998.

	Culture Groups		
	BY94	BY96	BY97
Starting Inventory (January 1, 1998)	34	103	210[a]
Eyed-Egg to Fry			
Undetermined	n/a	n/a	n/a
Mechanical Loss			
Handling	0	3	8
Jump-out	0	1	0
Non-infectious			
Lymphosarcoma	0	0	0
Other[b]	4	2	2
Infectious			
Bacterial	0	27[c]	0
Viral	0	0	0
Other	0	0	0
Maturation			
Mature Males[d]	4	0	0
Mature Females[d]	3	0	0
Other	0	0	0
Relocation			
Transferred In	23[e]	16[f]	0
Transferred Out[g]	0	60	0
Planted/Released[h]	44	0	0
Ending Inventory (December 31, 1998)	2	26	200

[a] Fall 1998 collections.
[b] Includes culling associated with cultural abnormalities, and all undetermined, non-infectious mortality.
[c] Mortality associated with bacterial kidney disease *Renibacterium salmoninarum* infection.
[d] Spawned at Eagle Fish Hatchery.
[e] Transferred from the Manchester Marine Laboratory to Eagle Fish Hatchery for distribution and spawning.
[f] Spring 1998 outmigrant collections.
[g] Transferred from Eagle Fish Hatchery to the Manchester Marine Laboratory for seawater rearing.
[h] Released for volitional spawning in 1998.

Table 3. Summary of losses and magnitude of mortality for three East Fork Salmon River captive chinook salmon culture groups reared at IDFG facilities in 1998.

	Culture Groups		
	BY94	BY96	BY98
Starting Inventory (January 1, 1998)	37	5	304[a]
Eyed-Egg to Fry			
Undetermined[b]	n/a	n/a	46
Mechanical Loss			
Handling	1	0	0
Jump-out	2	0	0
Non-infectious			
Lymphosarcoma	0	0	0
Other[c]	6	0	0
Infectious			
Bacterial	0	0	0
Viral	0	0	0
Other	0	0	0
Maturation			
Mature Males[d]	5	0	0
Mature Females[d]	23	0	0
Other[e]	6	0	0
Relocation			
Transferred In[f]	18	0	0
Transferred Out[g]	0	5	0
Planted/Released	0	0	0
Ending Inventory (December 31, 1998)	12	0	258[h]

[a] Fall 1998 “safety-net” progeny.
[b] Typical egg to fry mortality includes non-hatching eggs, abnormal fry, and swim-up loss.
[c] Includes culling associated with cultural abnormalities, and all undetermined, non-infectious mortality.
[d] Spawned at Eagle Fish Hatchery.
[e] Mature fish with non-viable gametes.
[f] Transferred from the Manchester Marine Laboratory to Eagle Fish Hatchery for distribution and spawning.
[g] Transferred from Eagle Fish Hatchery to the Manchester Marine Laboratory for seawater rearing.
[h] Number of fry ponded in January 1999.

Brood Year 1996

At the beginning of the reporting period, 177 Lemhi River, 103 West Fork Yankee Fork, and 5 EFSR brood year 1996 chinook salmon collected in the fall of 1997 were in culture at Eagle Fish Hatchery. In May 1998, 110 Lemhi River, 60 West Fork Yankee Fork, and EFSR fish were transferred, at smoltification, to the Manchester Marine Laboratory to complete rearing in seawater. Between May and June, 1998, 16 brood year 1996 West Fork Yankee Fork chinook salmon were collected as yearlings and transferred to Eagle Fish Hatchery. Circumstances of mortality for brood year 1996 chinook salmon are presented in Tables 1, 2, and 3. In 1998, approximately 36% of the West Fork Yankee Fork culture group collected in the fall of 1997 were lost to clinical bacterial kidney disease. Spring and fall West Fork Yankee Fork collection groups are being reared in isolation to prevent transmission of disease. At the end of the reporting period, 41 Lemhi River and 26 West Fork Yankee Fork fish remained in culture at Eagle Fish Hatchery. All brood year 1996 EFSR chinook salmon were transferred to the Manchester Marine Laboratory. On December 31, 1998, Lemhi River and West Fork Yankee Fork fall-collected chinook salmon averaged 111.5 g and 152.4 g, respectively. West Fork Yankee Fork Salmon River chinook salmon collected in the spring averaged 55.0 g.

Brood Year 1997

In November 1998, 147 Lemhi River and 210 West Fork Yankee Fork brood year 1997 chinook salmon collected in the fall were transferred from the Sawtooth Fish Hatchery to Eagle Fish Hatchery. No fall 1997 collections were made in the EFSR. Additional collections of brood year 1997 chinook salmon may occur in the Spring of 1998. At the end of the reporting period, 135 Lemhi River and 200 West Fork Yankee Fork fish remained on station at Eagle Fish Hatchery (Tables 1 and 2). Transfers for seawater rearing are planned for May 1999. At the end of the reporting period, Lemhi River and West Fork Yankee Fork chinook salmon averaged 16.2 g and 9.3 g, respectively.

Brood Year 1998

Approximately 300 eyed-eggs from 1998 EFSR spawn crosses were retained at Eagle Fish Hatchery and not distributed to streamside or instream incubation systems. The selection of eggs was based on nuclear and mitochondrial DNA data generated to guide brood year 1994 spawn crosses. At the end of the reporting period, 258 sac fry were on station at Eagle Fish Hatchery (Table 3).

Egg and Fish Transfers

In 1998, a total of 30,050 eyed-eggs produced from spawning events at Eagle Fish Hatchery were transferred to instream and streamside incubation boxes in the Lemhi River (9,324), West Fork Yankee Fork (3,451), and EFSR (17,275), (Table 4). With the exception of 15,236 eyed-eggs transferred to Jordan-Scotty boxes in the EFSR, all remaining eggs for each river system were transferred to Whitlock-Vibert boxes supported in large hatch environments (modified refrigerators) plumbed directly with spring water.

On March 6, 1998, brood year 1996 Lemhi River (N = 177), West Fork Yankee Fork (N = 103), and EFSR (N = 5) chinook salmon collected the preceding fall were transferred to Eagle Fish Hatchery. Between April 2, 1998 and June 2, 1998, an additional 16 brood year 1996 West Fork Yankee Fork chinook salmon were collected and transferred to the Eagle facility. No brood year 1996 East Fork Salmon River or Lemhi River fish were collected in the spring of 1998.

On May 4, 1998, 110 Lemhi River, 60 West Fork Yankee Fork, and 5 EFSR, brood year 1996 yearling smolts were transferred from Eagle Fish Hatchery to the Manchester Marine Laboratory for seawater rearing.

On June 25, 1998, maturing brood year 1994 Lemhi River (N = 33), West Fork Yankee Fork (N = 20), and EFSR (N = 16) chinook salmon were transferred from the Manchester Marine Laboratory to Eagle Fish Hatchery to complete maturation in freshwater. Fourteen brood year 1995 maturing Lemhi River chinook salmon were transferred on this same date. On September 2, 1998, an additional three West Fork Yankee Fork (brood year 1994) and two EFSR (brood year 1994) chinook salmon were transferred from the Manchester Marine Laboratory facility to Eagle Fish Hatchery.

Table 4. Summary of 1998 chinook salmon eyed-egg transfers to instream and streamside incubation boxes.

Destination	Number Of Eyed-eggs Transferred	Dates Transferred
Lemhi River Hayden Cr. Site	9,324[a]	11/2/98
West Fork Yankee Fork	3,451[b]	11/2/98
East Fork Salmon River	17,275[c]	11/2/98, 11/7/98

[a] All eyed-eggs produced at Eagle Fish Hatchery from brood year 1994 and 1995 Lemhi River chinook salmon planted in Whitlock-Vibert boxes in one streamside incubation system.

[b] All eyed-eggs produced at Eagle Fish Hatchery from brood year 1994 West Fork Yankee Fork chinook salmon planted in Whitlock-Vibert boxes in one streamside incubation system.

[c] Eyed-eggs produced at Eagle Fish Hatchery from brood year 1994 East Fork Salmon River chinook salmon planted in Whitlock-Vibert boxes (2,039 eggs) and Jordan-Scotty boxes (15,236 eggs).

On August 18, 1998, 39 brood year 1994 female and 10 brood year 1995 male Lemhi River maturing chinook salmon adults were transferred from Eagle Fish Hatchery to the Lemhi River and released for volitional spawning. Twenty female and seven male Lemhi River chinook salmon received radio transmitters. Nine and 11 of the 20 females originated from seawater and freshwater rearing treatments, respectively. Three and four of the seven males originated from seawater and freshwater rearing treatments, respectively.

On August 20, 15 brood year 1994 female and 9 brood year 1995 male Lemhi River maturing chinook salmon were transferred from Eagle Fish Hatchery to the Bear Valley Creek site and released. The Bear Valley Creek release group of 24 chinook salmon included two radio-tagged fish. One of the fifteen females and one of the nine males received transmitters. Both radio-tagged fish released to Bear Valley creek originated from the freshwater rearing treatment

On August 20, 1998, 35 and 9 maturing brood year 1994 West Fork Yankee Fork chinook salmon were released for volitional spawning. Seventeen of the 35 females received transmitters. Eleven and six of these fish originated from freshwater and seawater rearing treatments, respectively. Six of the nine brood year 1994 male chinook salmon released to the West Fork Yankee Fork were fitted with radio transmitters.

On November 24, 1998, 147 Lemhi River and 210 West Fork Yankee Fork brood year 1997 chinook salmon, collected as parr the preceding fall, were transferred from the Sawtooth Fish Hatchery to Eagle Fish Hatchery. No brood year 1997 EFSR fall collections were made.

Fish Releases and Monitoring

Lemhi River

Field observations were conducted from the August 18, 1998, release date through October 3, 1998. During this period, a total of 19 redds were identified in the stream area where the 49 captive chinook salmon ranged. The timing of redd construction ranged from September 5, 1998, through September 27, 1998. During the evaluation period, several wild/natural chinook salmon were observed in the release area making it difficult to draw conclusions regarding the contribution that captive outplants made. However, it is safe to state that a greater number of redds was observed than could have been built by the number of wild/natural chinook salmon observed in this stream section.

Twenty-seven of the 49 fish released to the Lemhi River were implanted with radio transmitters. Radio-tagged fish ranged over a stream area of approximately 16 km. At the end of our evaluation season, 19 transmitters had been recovered. Eleven of the 19 transmitters were recovered in the stream or on the stream bank without fish carcasses associated with them. Predators are suspected of moving carcasses and dislodging transmitters. Three of the 39 females released to the Lemhi River were recovered in an unspawned state with ovaries completely intact or partially ovulated. Four additional female carcasses were recovered with partially spawned ovaries (approximately 50% of eggs retained in carcass).

Bear Valley Creek

Two of the 24 captive chinook salmon released to the Bear Valley Creek evaluation section on August 20, 1998, were implanted with transmitters. Field evaluations occurred between the release date and October 3, 1998.

Following release, all fish remained in the vicinity of the release site for approximately one week. At the beginning of the second week of observation, fish began to range within the 2 km study section. While the majority of the captive outplants remained within the study section, two female carcasses were recovered downstream of the lower blocking weir approximately four miles at an irrigation diversion screen on Hayden Creek. In addition, three fish were observed above the natural barrier that acted as the upstream study section block; one of those was the radio tagged female. The radio-tagged female remained upstream of the natural barrier for 28 days, then dropped back down into the study area. The radio tagged male remained in the immediate vicinity of the release pool for the duration of the observation period.

Redd construction occurred between October 8, 1998, and October 28, 1998. During this period, a total of six redds were identified. Several direct observations of spawning-related behavior were made during the course of investigation. Chinook salmon with freshwater and seawater rearing histories were observed defending territory and constructing redds. In general, more observations were recorded of female outplants than male outplants. Only one observation of pairing was observed during the investigation. Fish with seawater rearing history appeared to be more aggressive and capable of adapting to the natural environment than fish with freshwater rearing history.

The radio-tagged female moved upstream of the release location and eventually moved upstream of the natural barrier at the upper end of the study section. This female remained upstream of the natural barrier for 28 days, and then dropped back down into the study area. Her carcass was recovered downstream of the lower weir, after the weir had been removed. The radio-tagged male remained in the pool where he had been released for the duration of the observation period. One redd was located within five meters of the release pool, however it was not known if the male had spawned with a female at this site. After the weir was removed this male was observed on October 13 downstream of the weir location, and appeared to be in very good condition. The tag was recovered one week later after the carcass was apparently eaten by a predator.

West Fork Yankee Fork Salmon River

Forty-four captively-reared chinook salmon were released in the West Fork Yankee Fork on August 21, 1998 (35 females, 9 males). Radio tags were placed in 17 females and 6 males. Observations of spawning-related behavior commenced on August 22, 1998, and ended on October 3, 1998. In general, telemetry investigations and behavioral observations occurred in the lower 10 km of the stream.

Following the release of captive adults, a total of four redds were identified in the West Fork Yankee Fork. Redd construction was observed between September 3, 1998, and September 27, 1998. Wild/natural chinook salmon were observed in and above the study section but appeared to have completed spawning prior to the release of captive adults. Therefore, the four redds we observed were attributed to the captive release. Most chinook

salmon spawning activity occurred between late evening and early morning. No direct observations of redd excavation or defense were made in the West Fork Yankee Fork in 1998.

Fifteen of the 23 radio transmitters were recovered in 1998. Five transmitter signals were lost almost immediately following release suggesting the possibility of post release mortality, fish migration from the study section, or transmitter malfunction. Six transmitters were recovered in the stream or on the stream bank without fish carcasses associated with them. Predators are suspected of moving carcasses and dislodging transmitters. Four female carcasses were recovered with eggs intact (not ovulated). Only one female carcass was recovered that appeared to have spawned successfully. Two carcasses were recovered in the vicinity of redds.

East Fork Salmon River

In 1998, the CSCPTOC recommended that all mature EFSR adults and several Lemhi River and West Fork Yankee Fork adults be retained in the hatchery and not released to spawn volitionally in the wild. All EFSR adults were retained for artificial spawning to reduce the risk associated with demographic extinction in the event that wild/natural adults failed to return to the system and that captively-reared adults failed to successfully spawn (zero to few adult chinook salmon were projected to return in 1998).

Hatchery Evaluations

Gamete Evaluations

Lemhi River—In 1998, 9,354 eyed-eggs were produced from spawn crosses developed with brood year 1994 female chinook salmon with freshwater (three females) and seawater (four females) rearing history. Eight brood year 1995 and two brood year 1996 males were used in the spawning design. No brood year 1994 Lemhi River males were available in 1998. Brood year 1995 males included four freshwater rearing history and four seawater rearing history fish. The two brood year 1996 males were from the freshwater rearing treatment at Eagle Fish Hatchery. Twenty-three unique sub-families were produced from 1998 spawn crosses. Mean fecundity and egg survival to the eyed stage of development for freshwater females averaged 953 eggs and 48.5%, respectively. Mean fecundity and egg survival to the eyed stage of development for seawater females averaged 2,367 eggs and 92.0%, respectively (Table 5). Prior to attempting fertilization, we culled eggs from two freshwater treatment females based on observations of substantial egg deformation, egg retention, yolk polarization, and discolored ovarian fluid. Eggs from all brood year 1994 females from the seawater treatment group were fertilized. Brood year 1994 female chinook salmon with freshwater rearing history averaged 470 mm in fork length and 953 g in weight. Seawater females (brood year 1994) averaged 534 mm in fork length and 1,308 g in weight. Age-3 (brood year 1995) males with freshwater rearing history averaged 397 mm in fork length and 756 g in weight. Mean fork length and weight for brood year 1995 males with seawater rearing history averaged 378 mm and 526 g, respectively. The two brood year 1996 males (freshwater rearing history) averaged 196 mm in fork length and 65 g in weight.

West Fork Yankee Fork Salmon River—Brood year 1994 females with freshwater rearing history (one fish) and seawater rearing history (two fish) produced a total of 3,565 eyed-eggs in 1998. One brood year 1994 freshwater rearing treatment male and three brood year 1994 seawater rearing treatment males were used in the spawning design. Mean fecundity for freshwater and seawater rearing groups averaged 2,377 eggs and 2,070 eggs, respectively. Mean egg survival to the eyed stage of development averaged 8.8% for females with freshwater rearing history and 83.3% for females with seawater rearing history (Table 5). No eggs were culled from females from either rearing treatment prior to attempting fertilization. Ten unique sub-families were produced from 1998 spawn crosses. Mean fork length for brood year 1994 females with freshwater and seawater rearing history averaged 560 mm and 490 mm, respectively. Mean weight for brood year 1994 freshwater and seawater females averaged 1,784 g and 1,091 g, respectively. Brood year 1994 males with freshwater rearing history averaged 425 mm in fork length and 862 g in weight. Mean fork length and weight for brood year 1994 males with seawater rearing history averaged 459 mm and 919 g, respectively.

East Fork Salmon River—In 1998, a total of 17,840 eyed-eggs were produced from EFSR spawn crosses completed at Eagle Fish Hatchery. Twenty-three brood year 1994 females (13 freshwater and 10 seawater rearing history fish), five brood year 1994 males (one freshwater and four seawater rearing history fish), and cryopreserved milt from 10 males was used in the spawning design. Milt from brood year 1994 EFSR males was cryopreserved in 1997. We did not attempt to fertilize eggs produced from six captive females (five freshwater and one seawater history fish) based on observations of substantial egg deformation, egg retention, yolk polarization, and discolored ovarian fluid. Mean fecundity and egg survival to the eyed stage of development averaged 1,590 eggs and 32.5% for brood year 1994 females from the freshwater rearing group and 2,080 eggs and 78.5% for brood year 1994 females from the seawater rearing group. Egg survival to the eyed stage of development for spawn crosses completed with cryopreserved milt averaged 20.1% and 20.6% for brood year 1994 females with freshwater and seawater rearing history, respectively (Table 5). Brood year 1994 females with freshwater rearing history averaged 532 mm in fork length and 1,676 g in weight. Mean fork length and weight for brood year 1994 females with seawater rearing history averaged 553 mm and 1,728 g, respectively. Mean fork length for brood year 1994 males with freshwater and seawater rearing history averaged 495 mm and 553 mm, respectively. Mean weight for these rearing groups averaged 1,376 g and 1,713 g, respectively.

Hatch Box Program

Eyed-eggs produced from the above spawn crosses were planted in streamside and instream incubation devices with the cooperation of Shoshone-Bannock tribal personnel. Preliminary eyed-egg-to-hatch data collected for streamside Whitlock-Vibert boxes protected in modified refrigerators suggests that survival was good. Survival to hatch for Lemhi River eggs incubated at the Hayden Creek site averaged 75%. Survival for individual incubation boxes ranged from 3% to 98%. Some modification of the incubation system at this location was necessary due to blockage, by algae, of the spring water intake plumbing. Egg survival to hatch for EFSR eggs incubated in Boulder Creek (a tributary of the EFSR) averaged 62%. Survival data for individual incubation boxes ranged from 29% to 87%. Survival data for eyed-eggs placed in Jordan-Scotty boxes in the mainstem EFSR and in incubation boxes in the West Fork Yankee Fork was not available at the time of this writing.

Table 5. Summary of 1998 spawning data for Lemhi River (LR), West Fork Yankee Fork Salmon River (WFYF), and East Fork Salmon River (EFSR) captive chinook salmon. Data for males reflects the use of fresh milt, except where noted. FW and SW reference freshwater and seawater rearing treatments.

Stock and Rearing History	Number of Unique Females Spawned	Number of Unique Males Spawned	Mean Female Fecundity	Mean Egg Survival to the Eyed Stage	Number of Eyed-Eggs Produced
LR—FW[a]	3	6	953	48.5%	2,779
LR—SW[b]	4	4	2,367	95.7%	8,005
WFYF—FW[c]	1	1	2,377	8.8%	168
WFYF—SW[c]	2	3	2,070	83.3%	3,397
EFSR—FW[d]	3	1 fresh 4 cryo	1,590	32.5% fresh 20.1% cryo	4,225 fresh 1,148 cryo
EFSR—SW[d]	10	4 fresh 6 cryo	2,080	78.5% fresh 20.6% cryo	11,363 fresh 1,104 cryo

[a] All females from brood year 1994. Four and two of the six males from brood year 1995 and 1996, respectively.

[b] All females from brood year 1994. All males from brood year 1995.

[c] All females and males from brood year 1994.

[d] Fresh and cryopreserved milt used in EFSR spawning matrix. Number of males, egg survival to the eyed stage of development, and number of eggs produced reported for spawn crosses conducted with fresh milt (fresh) and with cryopreserved milt (cryo).

Cryopreservation

On September 28, 1998, milt from maturing brood year 1994, 1995, and 1996 chinook salmon was cryopreserved at Eagle Fish Hatchery. Details of this event are presented in Table 6. On September 30, 1998, additional milt was harvested from maturing chinook salmon at Eagle Fish Hatchery and shipped to the University of Idaho and Washington State University for independent cryopreservation and storage. Both universities received milt from three brood year 1994 West Fork Yankee Fork males, five brood year 1994 EFSR males, and one brood year 1996 Lemhi River male. In addition, the University of Idaho and Washington State University received milt from seven brood year 1995 Lemhi River males and six brood year 1995 Lemhi River males, respectively.

On September 11, 1998, milt from 10 brood year 1994 EFSR males was transferred from the University of Idaho to Eagle Fish Hatchery. Cryopreserved milt was incorporated in the 1998 spawning design for EFSR adults at Eagle Fish Hatchery.

Fish Health

Trends in the detection of infectious disease agents have become apparent over the course of tracking individual chinook salmon stocks collected as wild parr/smolts for the development of captive rearing groups. Principal concerns include the presence of bacterial kidney disease (BKD), whirling disease (WD), and the presence of the parasitic gill copepod *Salmincola californensis.* A summary of disease concerns, highlighted by disease agent, is presented below.

Bacterial Kidney Disease—Bacterial kidney disease resulted in the loss of approximately 36% of the brood year 1996 West Fork Yankee Fork, fall-collected, rearing group during this reporting period. Although minimal, BKD also caused mortalities in brood year 1995 and brood year 1996 Lemhi River rearing groups. Conversely, BKD did not result in loss in brood year 1994 and brood year 1997 captive chinook salmon. We speculate that the relatively high degree of loss in brood year 1996, fall-collected, West Fork Yankee Fork chinook salmon is associated with the collection of a few heavily infected fish. Following collection and the confinement of all fish in one rearing tank, the disease became established in other individuals. For unknown reasons, this did not appear in other rearing groups. Measures to control BKD were expanded in 1998 to include interperitoneal injection of brood year 1997 stocks with Erythromycin shortly after the collection. In addition, brood year 1996 West Fork Yankee Fork and brood year 1994 Lemhi River stocks received interperitoneal injections in 1998. Rearing groups that did not receive interperitoneal injections periodically (28 d treatments two to four times per year) received Aquamycin medicated diet.

Whirling Disease—Wild chinook salmon parr/smolts collected from the Lemhi River (four brood years) are infected with *Myxobolus cerebralis*, the causative agent of whirling disease. Occasionally, deformities of the head and lower jaw are observed. The prevalence of infection in rearing groups from four brood years is about 38%. To date, no mortality has been directly attributed to the presence of this pathogen. Trials with Fumagillin, an experimental antibiotic, are currently underway at the IDFG Eagle Fish Health Laboratory to control the transmission of this disease.

Parasitism—Wild chinook salmon parr/smolts collected from the Lemhi River and reared in freshwater at Eagle Fish Hatchery are infected with the parasitic gill copepod *Salmincola californensis*. Extensive necrosis of gill tissues adjacent to anchor locations of parasites have been detected in brood year 1995 and brood year 1996 Lemhi River stocks. Thirty-two percent of the 1998 mortality in brood year 1996 Lemhi River chinook salmon is attributed to the presence of this parasite. Brood year 1995 Lemhi River chinook salmon are most heavily infected, but direct mortality as a result of parasitic infection has not been documented. However, feed response and growth dropped sharply in this rearing group during this reporting period. Control of infection involves manual “picking” of parasites. Currently, we are on a three-week schedule of manual parasite removal. This appears to have controlled infection and even to have reduced numbers of parasites noted per fish. Three chemical treatments are presently being investigated for safety with surrogate chinook salmon.

Table 6. Summary of September 28, 1998, milt cryopreservation activities at Eagle Fish Hatchery (BY = Brood Year, Lemhi River = Lemhi River, WFYF = West Fork Yankee Fork Salmon River, EFSR = East Fork Salmon River).

Rearing Group	Number of Males Used	Number of 0.5 ml Straws Cryopreserved	Average Milt Motility	Motility Range
BY94 WFYF	3	92	82.6%	50.0% to 100.0%
BY94 EFSR	4	112	93.7%	85.0% to 100.0%
BY95 LEMHI RIVER	7	208	95.1%	70.0% to 100.0%
BY96 LEMHI RIVER	1	22	90.0%	--

Virus—All chinook salmon mortalities associated with the captive-rearing program are examined for replicating viruses. To date, no viruses have been identified in the program. In 1998, additional precautions were put in place to examine all adult chinook salmon transferred from seawater rearing at the Manchester Marine Laboratory to Eagle Fish Hatchery. Ovarian fluid and tissue was blind pass tested in cell culture as an additional measure of investigation for the presence of viruses. This technique was incorporated into standard pathology protocols to ensure that every effort was made to investigate for the presence of the North American strain of viral hemorrhagic septicemia (recently identified in Washington waters approximately 1.6 km from the Manchester Marine Laboratory). Although not extremely virulent in salmonids, the detection of this pathogen could possibly preclude the interstate transfer of chinook salmon.

CONCLUSIONS

1) Captive rearing can be used to maintain minimum numbers of spawning adults for stocks that face demographic risks associated with low adult escapement or other environmental perturbations.

2) Hatchery protocols are in place to successfully rear juvenile chinook salmon through maturation.

3) Gamete quality in captively-reared chinook salmon (as measured in controlled hatchery spawning events) is sufficiently high and is not expected to limit the success of the captive rearing concept.

4) Captive female chinook salmon reared from smoltification through maturation in seawater produced higher egg survival to the eyed stage of development than captive females reared in freshwater.

5) Captive adults released to volitionally spawn developed search patterns, identified and defended territory, and constructed redds.

6) Captive adult chinook salmon reared from smoltification through maturation in seawater possessed better fin quality than chinook salmon reared exclusively in freshwater.

7) Post release behavior was judged to be potentially limiting for captive adults reared exclusively in freshwater.

8) Disease is a potentially limiting factor to the program. Wild parr and smolts may contract bacterial and parasitic diseases prior to collection. Disease may jeopardize survival in the hatchery.

9) Precocial male maturation and the lack of mature males at age-4 and 5 is a potentially limiting factor to the program.

RECOMMENDATIONS

1) Continue to refine fish culture protocols including rearing water temperature, feed ration, maturation sorting, and the administration of theraputants for the control of infectious disease.

2) Collect eyed-eggs instead of parr or smolts to initiate rearing groups for all stocks. Implementation of this protocol offers the best chance of equalizing family representation, equalizing initial sex ratio, reducing or eliminating the transmission of infectious disease, and reaching program rearing and release size objectives.

3) Emphasize seawater rearing to improve fin quality and subsequent performance following release for volitional spawning.

4) Increase the frequency of post release, adult field observations to better characterize performance and spawning success.

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